R E P O R T R E S U M E S

ED 014 890 EM 004 049

A DISCUSSION OF EDUCATIONAL TECHNOLOGY WITH EMPHASIS ON COMPUTER-ASSISTED INSTRUCTION.

BY- CHORVINSKY, MILTON
NATIONAL CENTER FOR EDUCATIONAL STATISTICS (DHEW)

REPORT NUMBER TN-29 PUB DATE 9 MAY 67
EDRS PRICE MF-$0.25 HC-$0.72 16P.

DESCRIPTORS- *COMPUTER ASSISTED INSTRUCTION, *EDUCATIONAL TRENDS, EDUCATIONAL TELEVISION, TEACHING MACHINES, PROGRAMED TUTORING, *HISTORICAL REVIEWS, PROGRAMED TEXTS

A DISCUSSION OF RECENT DEVELOPMENTS IN EDUCATIONAL TECHNOLOGY EMPHASIZES THE SIGNIFICANCE OF COMPUTER-ASSISTED INSTRUCTION (CAI). SOME OF THE ADVANTAGES, LIMITATIONS, AND POSSIBLE APPLICATIONS OF CAI SYSTEMS ARE MENTIONED. SOME CAI SYSTEMS NOW UNDER DEVELOPMENT ARE IDENTIFIED. (MS)

ED014890

Working Paper
Does Not Reflect
Official Policy of
The Office of Education

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

NATIONAL CENTER FOR EDUCATIONAL STATISTICS
Division of Operations Analysis

A DISCUSSION OF EDUCATIONAL TECHNOLOGY
WITH EMPHASIS ON COMPUTER-ASSISTED INSTRUCTION

by

Milton Chorvinsky

Technical Note
Number 29

May 9, 1967

EM 004 049

OFFICE OF EDUCATION/U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

NATIONAL CENTER FOR EDUCATIONAL STATISTICS
Alexander M. Mood, Assistant Commissioner

DIVISION OF OPERATIONS ANALYSIS
David S. Stoller, Director

A DISCUSSION OF EDUCATIONAL TECHNOLOGY WITH EMPHASIS ON COMPUTER-ASSISTED INSTRUCTION

The area of Educational Technology encompasses the use of a variety of teaching aids or devices to supplement instruction by the classroom teacher or lecturer. These devices include open- and closed-circuit educational television; video tape recordings and equipment; computerized instruction and student testing, evaluation and guidance systems; information storage, retrieval, and distribution systems; programmed instruction; teaching machines; microfilm and microfilm viewing equipment; 8 mm. films, and printing and projection equipment; and language laboratories.

One of the primary purposes in using these devices is to free the teacher from dealing with the class as a unit and enable him to work with individual students. The long-term trend of educational change is toward truly individualized learning, with each pupil or student progressing at his own rate.

Television and teaching machines were used fairly extensively when first used, but they have been used more selectively in recent years. Teaching machines are valuable in courses which require a great amount of drill and memorization, but have "obvious weaknesses in the study of music, literature, history, political science, and other courses where it is just as important to absorb ideas as it is to memorize facts."(1) The results of a survey of the use of teaching machines in some large school systems are discussed below.

---

(1) Joseph F. Kauffman, Education, (Washington, D.C.: Potomac Books, Inc., 1966).

Educational television (ETV) is considered in some quarters still to have a great potential. The book Imperatives in Education, published in 1966 by a special commission of the American Association of School Administrators, states that ETV has proved to be an excellent means for disseminating new information, new concepts and new teaching methods. It recommends the use of ETV at all school levels with programs produced by the school system using well-trained producers from the system's staff and master teachers. "It can be employed in the large group or class situation. It is a boon to the homebound child...It is used for enrichment programs; for bringing the expert from government, business, and industry to the student; for teaching cultural appreciation and art and music techniques; for stimulating health programs; and for inservice education of teachers."(2)

At present there are 132 educational stations, 63 of these operating on VHF channels. A well-known experiment in ETV is the Midwest Program on Airborne Television Instruction. High-flying planes circle over the Midwest and beam educational programs to six states. In this situation, the classroom teacher has no control over the lesson, nor does the local school superintendent, the community, or the individual states.

According to Education Summary, ETV needs a good steady supply of funds and a sense of direction.(3) The Ford Foundation has proposed a new broadcasting satellite system to finance noncommercial television with earnings from transmission of commercial television shows. The proposal calls for a new private corporation to launch and operate satellites for relaying all domestic network programs, both commercial and educational. There would be four channels for instructional television, one for home information and cultural broadcasts, and six for commercial shows.

---

(2) Imperatives in Education, American Association of School Administrators, (Washington, D.C., 1966).

(3) "ETV: Still Another New Day A-Dawning?," Education Summary, October 15, 1966, pp. 4-5.

A danger of a satellite educational system is its possible monopolization of instructional material. The Ford Foundation proposal is opposed by the Carnegie Commission on Educational Television, a non-profit, non-governmental organization financed by a mixture of private and Federal funds. The Carnegie Commission recommends a Corporation for Public Television, which would strengthen local and regional services and provide only occasionally for a live, fully interconnected network of ETV. The Commission wants to strengthen diversification, local responsibility, and independence in the educational television system. It claims that "cheap color TV recording and playback is near;" and that a teacher could pick up a library video recording, without waiting to tune in at a specified hour.(4) This fits in with the growth of closed-circuit television in schools. CCTV is suited for small student groups and for specialized subjects, and can present recordings from open-circuit broadcasts.

An area which is likely to have a significant effect on education over the long term is Computer-Assisted Instruction (CAI). This name has been given to instruction in which the individual student operates and responds to a display device which is controlled by the computer. The computer-centered system represents the most sophisticated type of teaching machine. Along with the other types of teaching machines, its design provides for student active participation, and for immediate reinforcement after each response. These types are:(5)

1. Programmed textbooks - in these the program is presented in either linear or restricted branched form and the student either writes his answer or chooses an answer which directs him to another page. Since the student has complete freedom of access to the material, these devices are not cheat-proof; and there is a tendency, in uncontrolled situations, for the student not to follow the instructions of the author.

---

(4) Education Summary, Op.cit.

(5) C.A. Thomas, I.K. Davies, D. Openshaw, and J.B. Bird, Programmed Learning in Perspective: A Guide to Program Writing, (Chicago: Educational Methods, Inc., 1963).

2. Simple manually operated teaching machines - these can employ linear or simple branching sequences. The program material is presented in such a way that the student does not have free access to it so that he is required to follow the prescribed instructions, and cheating is normally eliminated.

3. Electrically operated teaching machines employing 35 mm. projection techniques - these machines ensure that the student obeys the operating instructions and makes a definite overt response. They virtually eliminate the possibility of cheating. Because the program is presented on film, a very large number of frames can be stored in the machine; and, as a consequence, branching techniques can be employed.

4. Electrically operated machines which allow a variety of presentations and responses - linear or branching sequences can be employed in this type of machine and constructed or multiple-choice responses can be called for. The distinguishing feature of these machines is the fact that information can be presented to the student through a variety of media such as film, filmstrip, synchronized tape recorders, or written text. Similarly the student's response can take the form of a written, oral, or manipulative activity. These machines offer tremendous flexibility to the programmer.

The extent of use of teaching machines in large school systems was studied in a recent survey by the National Education Association Research Division and the American Association of School Administrators. Some of the results of the survey are given below. The results "disprove both the overly optimistic (revolutionizers of education) and the overly pessimistic (threat to personal quality in education) fads."(6)

A total of 443 school systems with 12,000 or more pupils were contacted. Of these, 126 systems in 44 states were identified as having used programmed texts and/or teaching machines for 378 applications of programmed instruction. Programmed texts were more popular than teaching machines. The latter were used by only 23 school systems. The elementary school subjects are short

---

(6) "Programmed Instruction in Large School Systems," Automated Education Letter, Vol. 2, No. 2, December 1966.

programs, the longest being a year-long foreign language program. At the secondary level, most of the programs are one semester in length with shorter programs in the science and social studies fields. The variation in program length is shown in Table I.

TABLE I

Time Required to Complete Programs

Length of Program	Number of Projects
1 week or less	20
2 to 4 weeks	54
1 to 3 months	71
1 semester	77
1 year	176

The use of programmed instruction in the 126 school systems increased each year following the first year of use, 1960-61. The distribution by grade in which PI was used is shown in Table II.

TABLE II

Grades in Which Programmed Instruction Was Used in 126 School Systems

Grade	Number of Systems	Percent of Total Systems	Number of Programs	Percent of 378 Programs
K	2	1.6%	2	0.5%
1	20	15.9	23	6.1
2	14	11.1	17	4.5
3	9	7.1	12	3.2
4	28	22.2	41	10.8
5	37	29.4	56	14.8
6	38	30.2	58	15.3
7	45	35.7	70	18.5
8	50	39.7	77	20.4
9	67	53.2	121	32.0
10	57	45.2	96	25.4
11	48	38.1	74	19.6
12	43	34.1	76	20.1

A summary is given below of the percentages of all applications of PI reported.

Percentage of Projects Used In:	Elementary Level	Secondary Level
Remedial Work	15.4%	28.1%
Enrichment	35.6	23.7
Regular Course Work	61.5	62.0

In a Computer-Assisted Instruction System, the student sits at a display terminal or station linked with the computer, which in some experimental systems is only a computer-controlled electric typewriter, but in others has such equipment as a random-access slide projector, cathode ray tube, light pen, and audio system in addition to the typewriter. When "perfected," the CAI system will provide, to a greater extent, the following advantages ascribed to the other types of teaching machine. A CAI system should provide accommodation for large individual differences in learning rates, teacher relief from routine tasks, and systematic ordering of curriculum sequences. Unlike other teaching machines, the CAI system should provide unprecedented data recording and analysis for the teacher's enlightenment. The teacher should have time to help individual students or small groups. He would also be provided with a large repertory of the highest-quality presentation of ideas and with specific curricular material which he needs.

Articles by various educational authorities express the opinion that general usage of computer-assisted instruction will not occur before a ten- to twenty-year period. R. Louis Bright, Associate Commissioner of the Bureau of Research of USOE, was noted by the October 15 issue of Education Summary as saying that it will take almost ten years to reach a feasible price for education-oriented computers and similarly complex electronic devices. He puts a ceiling of 25 cents per student hour on computer costs before they can appear in the typical public school budget.

It is difficult to imagine such low operating costs, since computers themselves are extremely expensive machines whether purchased or rented, and the cost of a single computer-linked teaching station may be a thousand dollars or higher. To this must be added the maintenance costs and the salaries of engineers, programmers, and other specialists. Professor Patrick Suppes of Stanford University, who is directing the development of an elementary school mathematics program using a CAI system (described below), has stated that with current technology and without involving large numbers of students, individualized work in arithmetic and spelling could be brought to school districts at a cost of $40 to $50 per student per year.(7) The writer feels that this is a very high price for the improvement of only two components of the curriculum. Professor Charles S. Benson of the University of California has stated that because computer-based instruction is expensive, "policy choices may have to be made as to which kinds of children are to receive...instruction like this and which are not." This is a difficult choice.(8)

In addition to high cost, an important limitation of computers as of all teaching machines is that they function according to their own organizational principles and not according to the principles of human behavior.(9) Therefore, it takes ingenious and imaginative programmers to arrange a course of study for computer control without losing something of its special flavor and organization. It is generally felt that, if programming is used too extensively, it may prevent the development of intuitive and creative thinking or destroy thinking when it appears. It is not yet clear, however, whether this defect is inherent in the concept of programming or is simply a function of its primitive state of development.

---

(7) Patrick Suppes, "The Computer and Excellence," Saturday Review, January 14, 1967.

(8) Charles S. Benson, "Measurement of Quality in Education," Science Education, Vol. 50, No. 3, April 1966, pp. 283-285.

(9) Karl U. Smith and Margaret F. Smith, Cybernetic Principles of Learning and Educational Design, (New York: Holt, Rinehart, & Winston, 1966).

A third limitation is the highly skilled nature of programming. Only a limited number of trained specialists understand how to program a computer for different purposes, and very few of these trained programmers are also educational specialists with definite ideas about how to program subject content for efficient learning. Computer manufacturers try to lessen this limitation by the development of special software, e.g., IBM's Coursewriter language.

While CAI systems appear to have the limitations discussed, there are a number of educators who are enthusiastic about its potential. One of these is Dr. John E. Champion, President of Florida State University, who said at the opening of its CAI Center that computer use for teaching and research may be the most significant technological contribution to education in this century and that CAI should become a conventional part of our instructional equipment and methodology within the next five years.(10) It is evident that in the course of time, several computer manufacturers, including IBM, GE, RCA, and Ford (Philco) will perfect CAI systems for parts of the elementary school curriculum and also for some college courses. A description of some CAI systems presently under development is given below.

Applications of CAI Systems

Several types of application of CAI systems may be distinguished. These include drill and practice, tutoring, testing, and simulation.

Drill and Practice

A natural application for CAI is the provision of practice and evaluation for a learner who needs extensive training.(11) The CAI system provides the objective learning conditions under which responses receive immediate evaluation and the provision for repeating those items that are presenting

---

(10) Automated Education Letter, Vol. 2, No. 1, November 1966, page 9.

(11) Duncan N. Hansen, "Computer Assistance with the Educational Process," Review of Educational Research, American Educational Research Association, Vol. 36, No. 5, December 1966, pp. 588-603.

difficulty to the learner. This application may occur even at the college level, on which the objective is often to build discrimination or vocabulary skills basic to some specified content area. Examples of the development of CAI programs in drill applications are: (1) the Stanford University group's daily linear mathematics program that reviews and teaches basic number facts to fourth-grade children--this became an integral part of the daily instructional activities of a school, (2) a Stanford experiment which provided a daily arithmetic drill to over 300 children in grades three to six, (3) an additional daily spelling activity for sixty intermediate-grade children. The learning curves for these spelling drills indicated significant improvement in the spelling competency of these elementary school children.

Tutoring

A tutorial program is difficult to define.(12) It can be distinguished from drill programs both in the diversity of the teaching frames and student-computer interaction and in the breadth of the content which it may encompass. Its objective is usually to impart a definite amount of information and concepts and induce the student to use the concepts properly. The method employed is question and answer with extensive branching to adapt to individual differences. The goal of the author is to anticipate all possible and important student difficulties and provide, like a good experienced human tutor, a sequence designed to cope with each difficulty.

A consistent finding associated with CAI tutorial applications is a marked saving in instructional time with no loss in post-instructional achievement test performance. This occurred in the case of a college descriptive statistics course, a course in Fortran programming for college students, and in the instruction of 3,000 airline ticket agents via a CAI application used for reservation purposes on airlines.

---

(12) C. Victor Bunderson, "Computer-Assisted Instruction at the University of Texas," Automated Education Letter, Vol. 2, No. 1, November 1966.

Testing

The Hansen article (footnote 11) lists testing as an application of CAI. According to the article, it has been proposed that CAI can provide the capability of a type of testing not ordinarily available in conventional procedures. The most important feature of CAI is the concurrent (on-line) analysis and decision making from multiple dependent measures. For example, one can collect and utilize response latency and confidence rating data to determine the exact test items to be presented. Emir H. Shuford refers to this as cybernetic testing. As recommended by Mager and Clark for efficient use of programmed instruction, branching a learner systematically through a test can maximize both the desired level of difficulty and the desired coverage of the test content.(13)

Simulation

Simulation emphasizes feedback to the student of the results of his decisions or actions on the simulated system. The student learns to modify his inputs to the system in order to achieve some objective. These programs often assume that the student already possesses whatever concepts and skills are necessary and must now use his knowledge in the complex simulated situation.

Another type of student-computer interaction, which is more a resource than a type of instructional program, is real time computation and rapid retrieval and display of documents and reports.

The article on CAI at the University of Texas gives some interesting opinions which are intended to refer to college-level use of CAI, but

---

(13) Mager, Robert F., and Clark, Cecil, "Explorations in Student-Controlled Instruction," Psychological Reports, Vol. 13, pp. 71-76, August 1963.

which may eventually hold true for the lower levels.[14] It states that the philosophy developing at the University of Texas is that the most promising application of CAI in the lecture type of course which comprises the bulk of undergraduate education will not come through replacing lectures with long tutorial programs. Rather, it will be through computerized testing, grading, and reporting, which can provide both the student and the teacher with immediate feedback to guide further efforts. Also, short tutorial or drill CAI programs may be used for remedial purposes at the instructor's descretion for students falling below minimum entry requirements or simulation programs used as enrichment or as laboratory experiences.

Some CAI Systems Under Development

The development of specialized computer-assisted instructional systems is under way at several universities. Instruction at the elementary school level is being studied at Stanford University. mentioned above, the University of Pittsburgh, and Florida State University. The Stanford and Pittsburgh experiments are discussed below. College-level courses are under development at Ohio State University, the University of California at Irvine (UCI), Pennsylvania State University, and the University of Texas.

The Stanford Group is using the first integrated CAI system, the IBM Instructional System, installed in an East Palo Alto elementary school. This system provides time-shared terminals, CRT's, 16 mm. film, light pen, keyboard, and audio. The main effort has been in the development of a mathematics program for the first grade. The children give their answers by a light pen (when it touches the screen, the coordinates of points touched are relayed to the computer) or by a keyboard. Some work has been done also in reading and mathematical logic.

The University of Pittsburgh Learning Research and Development Center, under Professor Robert Glaser, is developing a CAI system for teaching

---

(14) C. Victor Bunderson, Op.cit.

reading, mathematics, and science in an elementary school in Whitehall, Pennsylvania, near Pittsburgh. This work is primarily devoted to investigations and refinements of CAI terminal equipment.

Faculty members at Pennsylvania State University are using the Coursewriter language to prepare courses in modern mathematics, cost accounting, audiology, and engineering economics for presentation to students by means of a computer. A course author can employ a procedure which will record and store all student errors and response times. The system uses an IBM-7010 and an IBM-1410 computer configuration with remote IBM-1050 typewriter terminals. The main computer is located at Yorktown Heights, New York, and the typewriter terminals are located on the campus. A terminal contains a random-access slide projector and tape recorder attachment. Course material can be presented to a student by typeouts, slides, or tape recordings. In answering a question, the student types his answer at the terminal and it is relayed over long-distance telephone lines to the central computer.

The University of California at Irvine plans to participate in a joint research project with IBM which "should be significant as a model for developing computer-based instructional systems in colleges now faced with rapidly expanding student enrollment."(15) Professors at UCI will assist in the project by helping to develop automated lessons to aid students in assuming responsibility for individual learning at their own pace. The initial UCI computer facility (IBM 1410-1440-1448) will provide for more than twenty students at a time, with remote typewriter-like consoles in the library, classrooms, laboratories, and dormitories. The computers will also facilitate an evaluation of each student's progress from entrance to graduation, as well as the budgeting, payroll processing, and accounting functions.

---

(15) J.I. Goodlad, J.F. O'Toole, Jr., & L.L. Tyler, Computers and Information Systems in Education, (New York: Harcourt, Brace & World, Inc., 1966).

The Ohio State University is also installing a computer-based instructional system. It will involve two GE-636 time-sharing computers, eight small-scale GE-115 computers, and a number of display terminals. The displays will be located at strategic campus locations, including laboratories, classrooms, and selected faculty offices and research facilities.

The projects described above are not an exhaustive discussion of CAI efforts. They do indicate, however, the diversity of experimentation in progress.

Computers are proving useful in areas other than the instructional process. They are used in school systems for general business accounting, student accounting, information retrieval, and assistance in student counselling.